A CONNECTING ROD AND PISTON PIN ASSEMBLY

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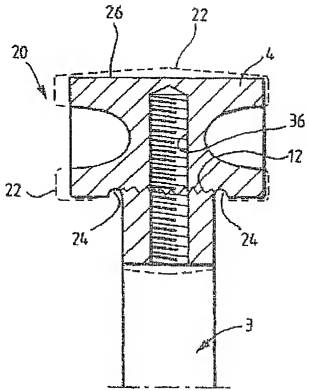
Abstract of **WO 0133114 (A1)**

Connecting rod (3, 30) and piston pin (4) assemblies and methods for the manufacture thereof are described. The connecting rod may be joined to a piston pin by welding (8,11) with the piston pin in situ in the piston (5). Suitable techniques may include friction welding or other methods such as laser or electron beam welding for example. Other methods of joining a connecting rod and piston pin together may include the techniques of fracture (12) splitting.



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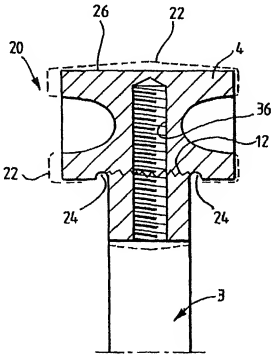

(57) Abstract: Connecting rod (3, 30) and piston pin (4) assemblies and methods for the manufacture thereof are described. The connecting rod may be joined to a piston pin by welding (8,11) with the piston pin in situ in the piston (5). Suitable techniques may include friction welding or other methods such as laser or electron beam welding for example. Other methods of joining a connecting rod and piston pin together may include the techniques of fracture (12) splitting.

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A CONNECTING ROD AND PISTON PIN ASSEMBLY

This invention relates to a connecting rod/piston pin assembly, particularly, though not exclusively, a connecting rod/piston pin for an internal combustion piston engine.

A known connecting rod comprises a body with a stem which connects an opening at one end, the little end, to an opening at the other end, the big end. A crank-pin of a crankshaft passes through the big end and a piston pin or gudgeon pin (hereinafter referred to as a "piston pin") passes through the little end. The piston pin also passes through bosses provided by the piston and which form an integral part of said piston. The piston pin has a cylindrical outer surface which is in contact with the piston boss and little end cylindrical bores and is constrained to rotate or oscillate about the longitudinal axis of the piston pin in one or both of these component bores. The piston pin may be fixed in the little end by means of an interference fit or otherwise, or it may be free to rotate in the little end in which case a bearing bush is frequently inserted into the little end. In both arrangements the little end consists of a cylindrical bore which is machined to close tolerances and whose axis is co-axial to those of the piston boss bores.

A feature of the above described arrangement is that the little end bore provides a continuous circumferential surface which encloses the piston pin and thereby separates

the piston bosses; an alternative arrangement with one piston boss and two co-axial little ends embracing said boss still requires that only part of the length of the pin may be used to come into contact with the piston to withstand the combustion loads on said piston. The high combustion loads in the engine subject the piston pin to bending stresses due to the longitudinally offset positions of the piston bosses with respect to the little end of the connecting rod. Attempts to reduce these stresses include the tapering of the connecting rod little end side faces, thereby permitting the upper part of the piston bosses nearest the crown of the piston to be brought closer together; this arrangement provides a greater length of the pin to come into contact with the piston on those surfaces which support the combustion loads.

According to a first aspect of the present invention, there is provided a method for the assembly of a connecting rod and a load-bearing piston pin to a piston, said piston including at least one piston pin boss to retain said piston pin: the method comprising the steps of inserting said piston pin into said at least one piston pin boss and attaching an end of a stem of said connecting rod remote from a big end thereof directly to said piston pin by welding.

According to a second aspect of the present invention, there is provided a connecting rod and piston pin assembly wherein an end of a stem of the connecting rod remote from a big end thereof is welded to said piston pin.

The piston pin may be generally cylindrical but may include features deviating from a true cylindrical form such as so-called "barrelling" for example. The criterion for the piston pin is that it must be able to oscillate in the piston boss or bosses in which it is located. At one extreme, the piston pin may be substantially spherical and oscillate within a spherically shaped boss in the form of a socket in the piston.

In the invention, the end of the connecting rod stem is immovably and directly connected to the piston pin with regard to the possibility of relative movement therebetween.

There may be only one piston pin boss or two piston pin bosses. Where there is one piston pin boss, at least the end of the connecting rod stem adjacent the piston pin may be bifurcated so as to embrace that part of the boss which sustains piston inertia loads during operation of an engine. Where there are two piston pin bosses the end of the connecting rod stem may lie between said piston pin bosses.

In a preferred embodiment, the piston pin boss or bosses may have an upper surface, which sustains the fuel combustion loads, in the form of a single continuous surface of contact between piston and pin to transmit the combustion loads on said piston to said connecting rod for substantially the full length of said pin.

In the present invention the use of a little end bore in the connecting rod is thus avoided and as a consequence it may be possible to reduce significantly the length of the said piston pin with associated reductions in bending stresses and reduced mass of the piston/piston pin/connecting rod assembly. The surfaces of those parts of the piston boss or bosses for transmitting inertia loads in the region of top dead centre may remain separated to allow the connecting rod stem to pass between. The transition between these two said surfaces of contact on the piston pin may take a variety of configurations that will depend on the machining requirements of the piston and the necessary clearance to allow the stem to pass and oscillate with respect to the piston. The angular arc, as measured about the longitudinal axis of said pin, of the contact surface between pin and piston which may be provided for substantially the whole length of the pin may be less than ninety degrees or up to more than one hundred and eighty degrees. The means of attachment of the stem to the piston pin may be by a variety of welding methods which may or may not ultimately permit the dismantling of the assembly.

One method involves the insertion of the piston pin into the piston bosses followed by the welding of the connecting rod stem directly to the pin. A particular method of welding is friction welding where the pin is brought into relative movement with the connecting rod and the two components are brought together to create sufficient heat from friction to result in plastic welding. Typically the

pin will be inserted into the piston and then either the whole assembly or the connecting rod will be rotated and both components will be brought into contact with each other with sufficient pressure and for a controlled time period to frictionally melt or plasticise a film of contacting surface; and thereafter ceasing said rotational driving while holding said surfaces together with sufficient forging pressure to allow the melted film to recrystallise and create a metallurgical bond between the faces on pin and stem. This method is both suitable for mass production and can also permit welding of a finish machined piston and connecting rod since the rod can be held at the correct alignment and distance to the pin during solidification to ensure that the big end bore and piston face needs no further machining. An advantage of this welding technique is the ability to weld a case hardened steel piston pin to a medium to low carbon or low alloy steel connecting rod; in addition there is the possibility to weld directly onto the cylindrical surface of the piston pin thus avoiding the need to machine circumferential features on said pin for the stem of the connecting rod to contact. The upset flash resulting from the weld may be left in situ or alternatively machined off.

Alternative methods to friction welding may include the techniques of laser welding, electron beam welding or plasma keyhole welding where these processes involve the minimum distortion and relative movement of the piston pin and connecting rod. However, any other suitable welding

methods able to join the piston pin to the end of the connecting rod stem may be employed.

According to a third aspect of the present invention there is provided a method of forming and joining a connecting rod and a load-bearing piston pin: the method comprising the steps of providing a connecting rod and piston pin unit, the piston pin being formed integrally with said connecting rod; separating said piston pin from said connecting rod by fracture splitting; machining a required cylindrical surface on said piston pin; machining suitable features on said piston pin and said connecting rod portions to enable them to be reconnected by mechanical fastening means; and, reconnecting said piston pin and said connecting rod together by mechanical fastening means.

It is to be noted that the method described above may include the recited steps in a different order and the invention is not to be limited to the specific order as recited. For example, the step of machining suitable features on the piston pin and connecting rod portions may be effected prior to the fracture splitting step such as by forming a treaded hole through the piston pin portion into the connecting rod portion from the pin side rather than providing threaded holes separately in these two portions after fracture splitting. In this way oil access features to the piston pin/piston pin boss running surfaces may be provided for example.

According to a fourth aspect of the present invention, there is provided a connecting rod and piston pin fastened together by mechanical fastening means wherein a mating interface between said connecting rod and said piston pin comprises a fracture split surface.

The mating interface between the rod and pin will thus consist of the reunited metal grains originally present in an integrally formed connecting rod and piston pin prior to fracture splitting.

An advantage of the third aspect of the present invention is that it avoids expensive machining of the piston pin and connecting rod stem to provide suitable alignment of the connecting rod big end bore to the piston axis, the pin and connecting rod stem may be made as a single piece and then separated by fracturing. Using such a method permits the subsequent machining of the piston pin and connecting rod separately while still ensuring the correct alignment and mating of the two pieces during assembly. Final machining of the connecting rod, such as the big end portion for example, may be done with the piston pin attached to the connecting rod stem. Engagement of the fractured surfaces assures correct alignment of the big end bore and piston pin axis. A further feature of this process may be the provision of the engaging fractured surfaces to lie within the projected cylindrical surface of the machined piston pin thereby permitting the pin to be passed through the piston bosses prior to reconnection of the piston pin and piston assembly to the connecting rod stem. To ensure that

the fracture surface lies in this position suitable notches may be provided on the integral piston pin/connecting rod unit prior to fracturing. Such notches may provided during the forming process of the integral rod and pin unit such as by pressing during a powder metallurgy forming route for example; subsequently by laser notching for example; or, by mechanical cutting means for example. However, any suitable method of notch forming, where employed, may be utilised. Finish machining of the piston pin may be performed using the same techniques as for traditional separate pins such as by cylindrical grinding, for example.

The mechanical fastening means may comprise a threaded screw for example. An important advantage of the method of the present invention conferred by the fracture surface is that the torque generated by turning a screw to fasten the rod and piston pin together is adequately resisted by the rough, intimately interlocking surface provided by the fractured metal grains and ensures the accurate required relative orientation of the axes of the piston pin, connecting rod and big end. Such accuracy of the axes would not be possible if the mating faces between the rod stem end and the piston pin were merely machined flat faces for example. Furthermore, it is not unusual during operation of an engine for torsional stresses to be developed between the piston/piston pin and connecting rod. Such torsional stresses are more effectively resisted by a fracture split surface at a lower tightening torque of the fastening means than with machined surfaces.

The connecting rod stem may include a bifurcated portion, for example, to allow access of the fastening means to the piston pin portion.

The integral connecting rod and piston pin may be formed by any suitable method such as, for example, casting, forging, powder compaction and sintering, powder forging, sinter forging.

The materials used for the connecting rod and piston pin unit may be any suitable for the eventual engine application and may include steels, cast irons, aluminium alloys, titanium alloys or composite materials, for example.

A co-operating piston may also possess a continuous load-bearing surface with the upper face of the piston pin as described above with regard to the first and second aspects of the present invention.

In order that the present invention may be more fully understood, examples will now be given by way of illustration only with reference to the accompanying drawings, of which:

Figures 1 and 2 show side views of one embodiment of a connecting rod and piston assembly according to the present invention;

Figures 3 and 4 show similar side views to Figs 1 and 2 of a second embodiment; and

Figures 5 and 6 show views at 90° to each other of the piston pin end of an integrally formed connecting rod and piston pin which have been fracture split from each other; and

Figures 7 and 8 show similar views to Figures 1 and 2 of the connecting rod and piston pin of Figures 5 and 6 assembled to a piston.

Referring now to the drawings and where the same features are denoted by common reference numerals.

Figures 1 and 2 show a connecting rod 1 comprising a big end opening 2, a stem 3 which is attached to a piston pin 4. A piston 5 has bosses 6 to hold said pin 4 and said bosses 6 provide a continuous upper load bearing surface 7 for the complete length of said pin to resist combustion forces on the piston crown. The stem 3 of the connecting rod 1 is attached to the piston pin 4 with a weld 8 that is achieved after assembly of the pin 4 into the piston bosses 6 using a known friction welding process. The piston/piston pin assembly and the connecting rod are rigidly held and mutually rotated under conditions of pressure therebetween until a layer of metal at the junction melts or becomes plastic whereupon the two components are stopped in a predetermined position relative to each other and a forging pressure is maintained until the metal at the weld 8 has

solidified. The length of the connecting rod 1 and the conditions of the friction welding process are carefully controlled such that the distance between the axes of the big end 2 and the piston pin 4 finish at a predetermined distance to each other. Some post-welding machining of the big end portion of the rod 1 may be effected to reach a final accurate spacing of the said axes.

Figures 3 and 4 show another embodiment of the assembly where there is a single piston boss 9 to withstand top dead centre inertia loads and the stem 3 separates to provide a forked or bifurcated portion 10 to form two points of attachment to the piston pin 4 such as the welds indicated at 11. The welds 11 may be achieved using laser, electron beam or plasma key hole welding; friction vibration welding may also be possible. In this embodiment, the piston pin 4 is again inserted into the piston boss 9 after being machined and the welds 11 are effected whilst the piston/piston pin assembly and connecting rod are held in the required mutual orientation. Again, some minor machining of the big end portion of the connecting rod may be effected after welding to ensure accuracy of the axes of the big end and piston pin and their mutual spacing.

The methods of Figures 1 to 4 provide for a reliable, low-mass and low-cost solution to the problem of continuous support of a piston undercrown region.

Figures 5 to 8 show another embodiment of the assembly where the pin 4 initially forms an integral part with the

stem 3 and said parts are fractured to separate them and thus permit assembly. An integral connecting rod and piston pin unit 20 are initially formed as shown by the outer dashed lines 22 in Figures 5 an 6. In its initial form, the unit 20 is produced by casting and forging of a single suitable piece of hardenable steel for example. Rough machining of the unit may be carried out prior to fracture. To control position of the fracture surface the unit 20 is provided with notches 24 which are forged or machined at suitable positions in the region of the transition between the stem 3 and pin 4. Case hardening of the unit or part of the unit may be effected prior to fracture so as to assist the formation of brittle surfaces for reliable re-assembly. In the example shown the fracture surface 12 is positioned, by virtue of the notches 24, to lie within the projected machined surface 26 of the pin 4. Thus, the finish machining of the piston pin may be performed so that the majority or all of the fracture surface 12 lies within the projected machined cylindrical surface 26 consequently enabling known machining techniques such as grinding to be employed. On re-assembly of the pin to the stem 3 of the connecting rod, there may be a small area of non-engaging fracture surface remaining on the connecting rod. Finish machining of the rod big end bore may be effected with or without the pin being assembled to the rod. Alignment jigs may be necessary to ensure correct engagement of the fracture surfaces particularly when the pin 4 is inserted in the piston bosses 6 prior to attachment of the rod to the pin. The rod stem 3 is in the form of two legs 30 having a space 32 therebetween to accommodate a bolt 16

which engages with a threaded hole 36 machined into the pin 4 after fracture splitting. In this embodiment again, there is continuous support 7 of the piston under crown surface along the whole length of the pin 4

The method of Figures 5 to 8 provides for low cost, accurate manufacture of a connecting rod and piston pin particularly in the case where there is continuous support of the piston crown underside along substantially the whole length of the piston pin.

Although the above embodiments have been described by way of reference to pistons wherein the piston undercrown region is supported along the entire length of the piston pin, the invention is equally applicable in those applications where the piston has two conventional pin bosses and the piston undercrown is unsupported by the piston pin between the piston bosses.

CLAIMS

1. A method for the assembly of a connecting rod and a load-bearing piston pin to a piston, said piston including at least one piston pin boss to retain said piston pin: the method comprising the steps of inserting said piston pin into said at least one piston pin boss and attaching an end of a stem of said connecting rod remote from a big end thereof directly to said piston pin by welding.

2. A method according to claim 1 wherein the welding technique is selected from the group comprising: friction welding; laser welding; electron beam welding; plasma keyhole welding; friction vibration welding; and, any other suitable welding technique.

3. A method according to either claim 1 or claim 2 wherein the piston is provided with a bore to accept the piston pin so that an undercrown portion of said piston is supported along substantially a whole length of the piston pin.

4. A method according to any one preceding claim wherein the piston is fully machined prior to insertion of the piston pin in the at least one piston pin boss.

5. A connecting rod and piston pin assembly wherein an end of a stem of the connecting rod remote from a big end thereof is welded to said piston pin.

6. A connecting rod and piston pin assembly according to claim 5 further including a co-operating piston assembled thereto.

7. A connecting rod and piston pin according to either claim 5 or claim 6 wherein an end of the connecting rod stem adjacent the piston pin is bifurcated so as to lie either side of a piston pin boss in a co-operating piston.

8. A connecting rod and piston pin assembly according to either claim 6 or claim 7 wherein said piston has a bore for accepting the piston pin wherein said pin supports an undercrown region along substantially a whole length of said piston pin.

9. A connecting rod and piston pin assembly according to any one of preceding claims 5 to 8 wherein the piston pin is generally cylindrical.

10. A connecting rod and piston pin assembly according to any one of preceding claims 5 to 8 wherein the piston pin is spherical.

11. A method of forming a connecting rod and a load-bearing piston pin: the method comprising the steps of providing a connecting rod and piston pin unit, the piston pin being formed integrally with said connecting rod; separating said piston pin from said connecting rod by fracture splitting; machining a required cylindrical surface on said piston pin; machining suitable features on said piston pin and said connecting rod portions to enable them to be reconnected by mechanical fastening means; and, reconnecting said piston pin and said connecting rod together by mechanical fastening means.

12. A method according to claim 11 wherein the step of machining suitable features on said piston pin and on

said connecting rod to enable fastening together thereof is effected prior to said fracture splitting step.

13. A method according to either claim 11 or claim 12 wherein said connecting rod and piston pin unit is provided with features to control the position of a fracture surface formed by said fracture splitting step.

14. A method according to any one of preceding claims 11 to 13 wherein a fracture surface formed by said fracture splitting step lies within a projected machined cylindrical surface of the piston pin portion.

15. A method according to any one of preceding claims 11 to 14 wherein the connecting rod portion and the piston pin portion are reconnected by a threaded fastener.

16. A method according to any one of preceding claims 11 to 15 wherein the connecting rod is provided with a bifurcated portion to receive a fastener.

17. A connecting rod and piston pin assembly fastened together by fastening means wherein a mating interface between said connecting rod and said piston pin comprises a fracture split surface.

18. A connecting rod and piston pin assembly according to claim 17 wherein the piston pin and connecting rod are held together by a bolt.

19. A connecting rod and piston pin assembly according to either claim 17 or claim 18 wherein a stem of the

connecting rod has a bifurcated portion to receive said fastening means.

20. A connecting rod and piston pin assembly according to any one of preceding claims 17 to 19 wherein said fracture surface lies within a projected cylindrical machined surface of said piston pin.

21. A connecting rod and piston pin assembly according to any one of preceding claims 17 to 20 further including a co-operating piston assembled thereto.

22. A connecting rod and piston pin assembly according to claim 21 wherein said piston has a bore for receiving said piston pin and said piston pin supports an undercrown region of said piston along substantially the whole length of the piston pin.

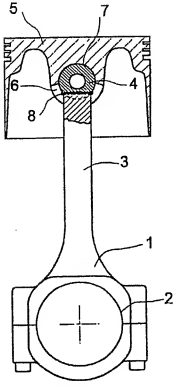

Fig 1

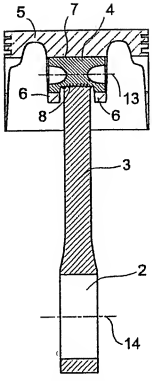

Fig 2

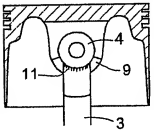

Fig 3

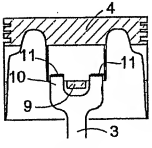

Fig 4

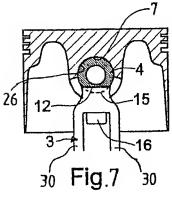

Fig.7

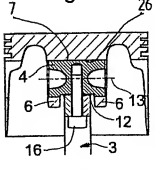

Fig.8

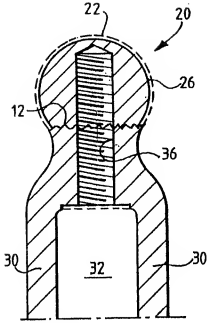

Fig.5.

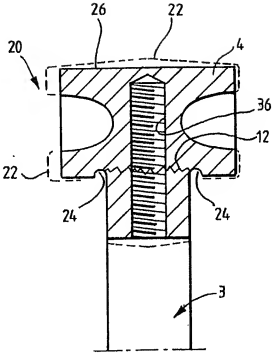

Fig.6.

INTERNATIONAL SEARCH REPORT

Inte. tional Application No
PCT/GB 00/04161

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F16J1/16 F16J1/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F16J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 36 02 576 A (MAHLE GMBH) 30 July 1987 (1987-07-30) column 2, line 31 -column 3, line 2 figures 1-3	1-3,8, 11-13, 15,17, 18,21,22
Y	DE 42 27 708 A (WOESSNER ECKART) 3 March 1994 (1994-03-03) column 1, line 50-58 figures 4,5	1-3,8
X		5,6,9
Y	US 5 507 093 A (WITTENSTEIN HORST ET AL) 16 April 1996 (1996-04-16) claim 3 figure 7	11-13, 15,17, 18,21,22

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
2 February 2001	14/02/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Van Wel, O

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INTERNATIONAL SEARCH REPORT

Int. .tional Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 012, no. 195 (M-705), 7 June 1988 (1988-06-07) & JP 63 001856 A (MATSUSHITA REFRIG CO), 6 January 1988 (1988-01-06) abstract	5,6,10
A	US 4 548 125 A (HUETHER WERNER) 22 October 1985 (1985-10-22) column 1, line 65 -column 2, line 4 figures 1,2	7,16,19
A	DE 296 08 749 U (SPECK AXEL DIPL ING) 11 July 1996 (1996-07-11) claim 1 figures 1-4	8,22

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Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. ional Application No
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